Three-Dimensional Structure and Evolution of Propagating Disturbances in the Marine Layer of the US West Coast: Analysis of 1996 Aircraft Observations

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LONG-TERM GOALS

This project is part of the Coastal Meteorology Accelerated Research Initiative (ARI), and as such has the following long-term goal: To develop an understanding of the genesis, propagation and decay of coastally trapped disturbances (CTDs) along mountainous coastlines.

OBJECTIVES

The meteorological focus in this ARI is the propagating, coastally trapped southerly surge, which typically occurs several times each warm season along the U.S. west coast. During the time our instrumented aircraft was on the west coast (June 1994, and late May through September 1996) six southerly wind episodes were measured: the June 1994 event was a southerly surge that lasted approximately two days, three of the 1996 episodes had a surge component, one event should have produced a southerly surge but did not, and one event was a transition to synoptic scale southerlies without a surge component. Our principal scientific activity in the present grant is to use these new data to obtain a more definitive view of the three-dimensional spatial structure and temporal evolution of southerly surges.

APPROACH

Our flights have gathered the only data set that can provide a direct look into the anatomy of the airflow and stratification over the coastal waters during a southerly surge. Towards this end, vertical sections of potential temperature and wind velocity have been constructed showing "slices" through the four surge cases. In addition to revealing this structure, the continuous wind velocity, temperature and humidity profiles measured by the aircraft can give accurate and continuous profiles of stratification, Richardson number and Froude number. Comparisons with other observations from fixed, synoptic-scale observational instrumentation and with numerical simulations of southerly surge events are providing insight into the relative importance of Kelvin wave dynamics, gravity current effects and synoptic-scale forcing.

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WORK COMPLETED

All 1996 data have been processed in essentially the same fashion as were the 1994 data [*Bane et al.*, 1995]. This involved editing and cleaning the data sets to eliminate clearly bad data values, aligning all data time series to a common time standard, conversion of measured variables to scientific units using calibration information, and computation of atmospheric variables from measured variables (*e.g.* the wind computation requires the combination of several measured variables, including aircraft heading and airspeed, air temperature, air pressure, aircraft groundtrack and groundspeed). During FY 1997 all data sets were transferred from the aircraft computers to the workstations in Chapel Hill, and initial processing steps were applied in order to provide first looks at some of the more interesting cases. Refinements to several sections inproved the quality of the data presentation, and these sections are now displayed on our project website [http://www.marine.unc.edu/cool/mbl/] and have been discussed in the publications listed below.

RESULTS

The four southerly surge cases that we measured include two surges between Point Conception and Point Reyes (June 1994 and June 1996) and two surges between Point Reyes and Cape Blanco (July and September 1996). Temperature and velocity sections from these surges suggest that each has a southerly flow leading edge above the MBL, similar to that first seen in the June 1994 case. These observations strengthen the notion that the complex vertical structure observed in June 1994 is the typical situation as opposed to an isolated occurrence. A correct dynamical understanding must then include an explanation of this aspect of the structure. Recent synoptic-scale analyses are strongly suggestive as to why two of the four aircraft-observed cases have some structural differences from the other two. Differing jet stream paths imply that upper-level support is present in two cases, while it is weak or absent in the others. This is consistent with the appearance of southerlies above the marine layer disturbance in the two cases with the upper-level support. Although these suggestions remain tentative at this point, they should provide insight into the relative importance and case-to-case variability of the synoptic scale forcing of CTDs.

IMPACT/APPLICATION

Already we are beginning to refine our view of the dynamical nature of these events based on the aircraft sections. Structural comparisons among four surges were discussed by *Bane* [1996, 1997a,b], and the structural features of the June 1994 event were compared with non-linear Kelvin Wave theory in *Ralph et al.* [1998]. The new aspect of the *Ralph et al.* study is that it describes the surge to be a Kelvin wave in the marine boundary layer inversion (MBLI) as opposed to a wave within the mixed layer. The mixed layer retains a constant thickness throughout the event, whereas the MBLI supports a wave propagating over a rigid lower boundary, which is the top of the mixed layer immediately below the MBLI. In other words, it is the MBLI that is the active participant in the surge and the mixed layer motions follow the development of the wave in the MBLI.

TRANSITIONS

Comparisons between our aircraft surge observations and COAMPS simulations of these events produced at NRL-Monterey are being made. The first comparisons, on two of the four cases, were

reported in *Thompson and Bane* [1998]. The structural features in the observed and simulated wind and temperature fields are quite similar, but differences in detail suggest that the COAMPS simulations may be improved even further. This work is continuing, with the aims of understanding the model-observational differences and providing the best possible forecasts.

RELATED PROJECTS

The collection and analysis of the data in this project have been coordinated with the other investigations supported by the Coastal Meteorology ARI. Additional collaborations have been established with the NSF-supported *Coastal Waves* 96 project of David Rogers and Clive Dorman [*Rogers et al.*, 1998], and we have been working closely with Wendell Nuss at NPS and William Thompson at NRL-Monterey on the model-data comparisons described above.

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